**U.S. FISH AND WILDLIFE SERVICE**
**SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM**

SCIENTIFIC NAME: *Gammarus hyalleloides*

COMMON NAME: diminutive amphipod

LEAD REGION: Region 2

INFORMATION CURRENT AS OF: April 2010

STATUS/ACTION:

___ Species assessment - determined species did not meet the definition of endangered or threatened under the Endangered Species Act (Act) and, therefore, was not elevated to Candidate status
___ New candidate
_X_ Continuing candidate
    _X_ Non-petitioned
    ___ Petitioned - Date petition received:
        _ 90-day positive – Federal Register (FR) date:
        _ 12-month warranted but precluded - FR date:
        _ Did the petition request a reclassification of a listed species?

FOR PETITIONED CANDIDATE SPECIES:
a. Is listing warranted (if yes, see summary of threats below)? NA
b. To date, has publication of a proposal to list been precluded by other higher priority listing actions?
c. If the answer to a. and b. is "yes", provide an explanation of why the action is precluded.

___ Listing priority (LP) change
    Former LP: ___
    New LP: ___

Date when the species first became a Candidate (as currently defined): May 11, 2005

___ Candidate removal: Former LP: ___
    ___ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
    ____U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.
    ___ F – Range is no longer a U.S. territory.

___ I – Insufficient information exists on biological vulnerability and threats to support listing.
___ M – Taxon mistakenly included in past notice of review.
___ N – Taxon does not meet the Act's definition of "species."
___ X – Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Crustacean, Gammaridae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Texas

CURRENT STATES/ COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE: Texas, Reeves and Jeff Davis counties

LAND OWNERSHIP: Land ownership is about 25 percent Federal (Phantom Lake Spring – Bureau of Reclamation (Reclamation) owns 17 acres (ac) (6.9 hectares (ha)) around the spring); 25 percent State (San Solomon Spring – Balmorhea State Park, Texas Parks and Wildlife Department (TPWD) owns 46 ac (18.6 ha) around the spring); 50 percent private (East Sandia Spring – The Nature Conservancy (TNC) owns 240 ac (97 ha) around the spring, and Giffin Spring – private local landowner). The following acreage estimates are based on actual surface water assumed inhabited at each spring location: Phantom Lake Spring = 0.07 ac (0.03 ha); San Solomon Spring = 8 ac (3.2 ha); East Sandia Spring = 0.07 ac (0.03 ha); and Giffin Spring = 1 ac (0.4 ha). Lands in watersheds surrounding the spring habitats are all privately owned.

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BIOLOGICAL INFORMATION

<u>Species Description and Taxonomy</u>: The diminutive amphipod (*Gammarus hyalleloides*) was first collected by W.L. Minckley from Phantom Lake Spring in 1967 and was formally described by Cole (1976, pp. 80-85). The name comes from the species being considered the smallest of the known North American fresh-water *Gammarus* amphipods. Adults range in size from 0.20 to 0.24 inches (in) (5 to 8 millimeters (mm)).

This is one species of a related group of amphipods from the Pecos River Basin, referred to as the *Gammarus-pecos* complex (Cole 1985, p. 93; Lang *et al*. 2003, p. 47; Gervasio *et al*. 2004, p. 521). In Cole's (1985, pp. 101-102) description of these amphipods based on morphological measurements, he considered *G. hyalleloides* to be endemic only to Phantom Lake Spring and amphipods from San Solomon and Diamond Y springs were considered to be *G. pecos*. However, recent genetic analysis provides strong evidence that the Toyah Basin populations (Phantom Lake, San Solomon, Giffin, and East Sandia springs) form a separate, distinct group from *G. pecos* (Gervasio *et al*. 2004, pp. 523-530). Genetic analysis suggests that *G. pecos* occurs only at Diamond Y Spring (Cole and Bousfield 1970, pp. 94-95; Seidel *et al*. 2009, p. 2309) and *G. hyalleloides* and the other Toyah Basin amphipod populations form a taxonomically unresolved group (Gervasio *et al*. 2004, pp. 523-530). Seidel *et al*. (2009, p. 2309) concluded that *G. hyalleloides* was limited to Phantom Lake Spring and the *Gammaras* at the other Toyah Basin springs (San Solomon, Giffin, and East Sandia springs) should be considered undescribed. It is unclear whether the results are sufficiently conclusive to warrant consideration of these populations as separate species.

Based on the best available science, we will consider the amphipod population at Phantom Lake Spring to be the same species as the other three Toyah Basin populations (i.e., San Solomon, Giffin, and East Sandia springs). These populations are being treated as one taxon. However, some genetic differences among these populations were detected, and more detailed phylogenetic analysis may lead to additional species being described from within this group (Gervasio *et al*. 2004, pp. 523-530; Seidel *et al*. 2009, p. 2311). If future study separates these four populations into more than one taxon, each should still be considered warranted for inclusion as a candidate for listing, due to the high degree of threats to the habitat. Thus, we have carefully reviewed the available taxonomic information to reach the conclusion that *G. hyalleloides* is a valid taxon.

<u>Historical and Current Range/Distribution</u>: The diminutive amphipod is endemic to the Toyah Basin of the Pecos River drainage of Texas. It is one species of a distinct group of amphipods that are restricted to euryhaline (having a wide range of salinities) desert spring systems in southeast New Mexico and west Texas (Cole 1985, p. 93). It is thought that these freshwater amphipods are derived from a widespread ancestral marine amphipod that was isolated inland during the recession of the Late Cretaceous sea, about 66 million years ago (Holsinger 1967, pp. 125-133; Lang *et al*. 2003, p. 47). They likely evolved into distinct species during recent dry periods (since the Late Pleistocene, ca. 100,000 years ago) through allopatric speciation (that is, speciation by geographic separation) following separation and isolation in the remnant aquatic habitats associated with springs (Gervasio *et al*. 2004, p. 528). Such divergence has been well-documented for aquatic and terrestrial macroinvertebrate groups within arid ecosystems of western North America (e.g., Bowman 1981, p. 15).

The diminutive amphipod occurs in only four springs in Jeff Davis and Reeves counties, Texas: Phantom Lake, San Solomon, Giffin, and East Sandia springs (collectively referred to here as the San Solomon Springs System) (Gervasio *et al*. 2004, pp. 520-522). These springs are all within about 8 miles (mi) (13 kilometers (km)) of each other. There is no available information that the species' historic distribution was larger than the present distribution. However, other area springs may have contained the same or similar species, but because these springs have been dry for many decades (Brune 1981, pp. 256-263, pp. 382-386), there is no opportunity to determine the potential historic occurrence of amphipods.

Other species of concern share a similar distribution, including two endangered fishes, Comanche Springs pupfish (*Cyprinodon elegans*) (Echelle 1975, pp. 529-530), Pecos gambusia (*Gambusia pecos*) (Echelle *et al*. 1989, p. 160-162), and two hydrobiid aquatic snails that are candidates for listing, Phantom Cave snail (*Cochliopa texana*) and Phantom springsnail (*Tryonia cheatumi*). Some differences occur in the distribution of these species compared to the diminutive amphipod. Pecos gambusia occurs in other spring systems outside the Toyah Basin, and the Comanche Springs pupfish has not been documented from East Sandia Spring in recent years (Service 1983, p. 4). Also, the federally threatened Pecos sunflower (*Helianthus* *paradoxus*) occurs only at East Sandia Spring in the Toyah Basin and in other areas of Texas and New Mexico.

Habitat: The diminutive amphipod only occurs in desert spring outflow channels. The small amphipods occur on substrates, often within interstitial spaces on and underneath rocks and within gravels (Lang *et al*. 2003, p. 49), and are most commonly found in microhabitats with flowing water. They are also commonly found in dense stands of submerged vegetation, primarily *Chara* beds (Cole 1976, p. 80). Because of their affinity for constant water temperatures, they are most common in the immediate spring outflow channels, usually only a few hundred meters downstream of spring outlets.

Amphipods play important roles in the processing of nutrients in aquatic ecosystems (Pennak 1989, pp. 476-477). Amphipods are considered sensitive to changes in aquatic habitat conditions (Covich and Thorpe 1991, pp. 676-677) and are often considered ecological indicators of ecosystem health and integrity. Amphipods from the *G. pecos* complex are considered highly imperiled, suggesting a systemic deterioration of aquatic ecosystems in the desert springs where they occur, based mostly on declining spring flows (Lang *et al*. 2003, p. 48).

Population Estimates/Status: Within its limited range, diminutive amphipod can be very abundant. For example, in May 2001, Lang *et al*. (2003, p. 51) estimated mean densities at San Solomon, Giffin, and East Sandia springs of 6833 amphipods/$m^2$ (636 amphipods/$ft^2$) (standard error ±5416/$m^2$; ±506/$ft^2$), 1167 (109) (±730/$m^2$; ±68/$ft^2$), and 4625 (432) (±804/$m^2$; ±75/$ft^2$), respectively. No data are available for Phantom Lake Spring densities, as the amphipod was not found there at the time of these surveys.

THREATS:

We have no new information as of April 2010 regarding threats to the species.

A. The present or threatened destruction, modification, or curtailment of its habitat or range.
Water Quantity: The primary threat to the continued existence of the diminutive amphipod is the degradation and eventual loss of spring habitat (flowing water) due to the decline of groundwater levels of the supporting aquifer. The San Solomon Spring System is located in the Toyah Basin at the foothills of the Davis Mountains near Balmorhea, Texas. In addition to being an important habitat for rare aquatic fauna, area springs are also an important source of irrigation water for the farming communities in the Toyah Basin. Phantom Lake Spring is in Jeff Davis County, while the other major springs in this system are in Reeves County. The Water District diverts water from the springs using a system of canals to irrigate area fields.

Pumping of the regional aquifer for agricultural production of crops has resulted in the drying of other springs in this region (Brune 1981, pp. 258-260). Other springs that have already failed include Comanche Springs, which was once a large surface spring in Fort Stockton, Pecos County, Texas (about 50 mi (80 km) east of Balmorhea). Prior to the 1950s, this spring flowed at more than 42 cubic-feet per second (cfs) (1.2 cubic meters per second (cms)) (Brune 1981, p. 358) and provided habitat for rare species of fishes and invertebrates, likely including aquatic snails and amphipods. The spring ceased flowing by 1962 (Brune 1981, p. 358). Leon Springs, located about 40 mi (64 km) east of Balmorhea in Pecos County, was measured at 18 cfs (0.5 cms) in the 1930s and was also known to contain rare fish, but ceased flowing in the 1950s following significant irrigation pumping (Brune 1981, p. 359).

The general physiographic setting of the spring system is that of a largely alluviated, arid, karst terrain. The aridity of the region restricts the available habitat for spring-dependent species and limits the available recharge to replenish and maintain spring flow. Surface waters in the area that provide habitat for the amphipods are exclusively supported by spring flows that discharge from groundwater aquifers. Many of the aquifers in west Texas receive little to no recharge (Scanlon *et al*. 2001, p. 28) and are influenced by regional flow patterns (Sharp 2001, p. 41). Management and conservation of these aquifers is the key for ensuring the continued survival of rare species in the spring habitats (Bowles and Arsuffi 1993, p. 327). Historically, the springs in this spring system were likely periodically interconnected as portions of the Toyah Creek watershed. In recent times, manmade structures altered the patterns of spring outflows and stormwater runoff from the watershed.

The base flows from these springs are likely discharge points of a regional flow system from aquifers associated with the Salt Basin, west of the Delaware Mountains, and Wildhorse Flat, west of the Apache Mountains, Culberson County (Sharp 2001, p. 42; Sharp *et al*. 2003, pp. 8-9; Texas Water Development Board 2005, p. 106). The relationships of the supporting aquifers for the springs are not fully defined. However, studies (LaFave and Sharp 1987, p. 9; Schuster 1997, p. 97; Sharp *et al*. 1999, pp. 2-4) indicate that "base flow" comes from a regional groundwater system, while the springs respond to runoff from the Davis Mountains, sometimes resulting in flow spikes following rainfall events. Similar water chemistry, water age, and near constant temperatures of about 79 degrees Fahrenheit ($^{o}$F) (26 degrees Celsius ($^{o}$C)) among three of the area springs (Phantom Lake, San Solomon, and Giffin) indicate that their waters likely originate from the same source of Cretaceous Limestone (Schuster 1997, pp. 43-44). East Sandia waters are likely a result of shallower, local groundwater sources (Schuster 1997, pp. 92-93).

An assessment of the springs near Balmorhea by Sharp (2001, p. 49) concluded: "The effects of humans on the Toyah Basin aquifer have been significant. Irrigation pumpage increased rapidly after 1945. Many springs in the area have since ceased to flow (Brune 1981, pp. 382-383). Irrigation pumpage from the Toyah Basin lowered water-table elevations and created a cone of depression (that is a lowering of the groundwater elevation around pumping areas). Thus, pumpage totals altered the regional-flow-system discharge zone from the Pecos River to irrigation wells within the Toyah Basin (Schuster 1997, pp. 16-19; Boghici 1997, pp. 100-108). Recent declines of pumpage for irrigation because of economic conditions have allowed partial recovery of water levels, but it seems doubtful that predevelopment conditions will be achieved."

Ashworth *et al*. (1997, pp. 1-13) provided a brief study to examine the cause of declining spring flows in the Toyah Basin. The conclusion from this study suggested that recent declines in spring flows are more likely to be the result of diminished recharge due to the extended dry period rather than from groundwater pumpage (Ashworth *et al*. 1997, p. 5). Although certainly a factor, drought is unlikely the only reason for the declines because the drought of record in the 1950s had no effect on the overall flow trend (Allan 2000, p. 51; Sharp 2001, p. 49). The Texas

Water Development Board (2005, pp. 1 -120) provided a thorough review of the hydrogeology and the regional flow system for the springs that support this species. The complexity of the aquifer system and the limited availability of data result in a high level of uncertainty about the cause of spring flow declines. However, the report concluded that, "…if most of the base flow to the springs consists of ancient groundwater that accumulated long ago, any extraction of this water from the system anywhere along the flow path may adversely affect water levels" (Texas Water Development Board 2005, p 108).

*Phantom Lake Spring*: Phantom Lake Spring is located at the base of the Davis Mountains, about 4 mi (6.4 km) west of Balmorhea State Park, just over the Reeves County line in Jeff Davis County. The 17-ac (6.9-ha) site around the spring and cave opening is owned by the Bureau of Reclamation (Reclamation). The site includes a 394 foot (ft) (120 meter (m)) pupfish refuge canal and is surrounded by an outcrop of limestone cliffs. When water was present from the spring, it was an important site for wildlife, especially small mammals, bats, and birds.

Historically, Phantom Lake Spring was a large desert ciénega with a pond of water more than several acres in size (Hubbs 2001, p. 307). Ciénega is a Spanish term that describes a spring outflow that is a permanently wet and marshy area. The spring outflow is at about 3,543 ft (1,080 m) in elevation and previously provided ideal habitat for the endemic native aquatic fauna. Flow from Phantom Lake Spring was originally isolated from the other waters in the system, and the spring discharge quickly recharged back underground before reaching Toyah Creek. Modifications to the spring outflow channeled waters into Toyah Creek, west of San Solomon and Giffin springs for use by local landowners and irrigation by the Water District. Flows from Phantom Lake Spring have been declining since measurements were taken in the 1930s, (Brune 1981, p. 259) and have not been sufficient to support irrigation by the Water District since the 1990s. During the 1940s the spring outflow was modified into a concrete-lined irrigation ditch so that the total outflow from the spring could be captured and used for irrigation of agriculture lands (Bogener 2003, pp. 4-5). The native aquatic fauna persisted, though probably in reduced numbers, in the small pool of water at the mouth of the spring (Phantom Cave) and in the irrigation canals downstream.

Phantom Lake Spring has experienced a long-term, consistent decline in spring flows. Discharge data have been recorded from the spring six to eight times per year since the 1940s by the U.S. Geological Survey (Schuster 1997, p. 90). The record shows a steady decline of flows, from greater than 10 cfs (0.3 cms) in the 1940s to 0 cfs (0 cms) in 2000. The data also show that the spring can have short-term flow peaks resulting from local rainfall events in the Davis Mountains (Sharp *et al*. 1999, p. 4). These flow peaks are from fast recharge and discharge through the local aquifer system. The flow peaks do not reflect direct surface water runoff because the outflow spring is within an extremely small surface drainage basin which is not connected to drainage basins from the Davis Mountains upslope. However, after each increase, the base flow has returned to the same declining trend within a few months. The exact causes for the decline in flow from Phantom Lake Spring are unknown. Some of the possible reasons are groundwater pumping of the supporting aquifer and decreased recharge of the aquifer from drought (Sharp *et al*. 1999, p. 4; Sharp *et al*. 2003, p. 7).

Exploration of Phantom Cave by cave divers has led to additional information about the nature of the spring and its supporting aquifer. Beyond the entrance, the cave is a substantial conduit that transports a large volume of water generally from the northwest to the southeast, consistent with regional flow pattern hypothesis. Over 8,000 ft (2,438 m) of the cave conduit have been mapped. In addition, flows have been measured and are in the 25 cfs (0.7 cms) range. The relatively small historic flow at Phantom Lake Spring is essentially an overflow of a larger flow system underground. Waters from Phantom Lake Spring issue at a higher elevation than other springs in the system, resulting in Phantom Lake Spring being the first to be impacted by declining groundwater levels.

A pupfish refuge canal was built by Reclamation in 1993 (Young *et al*. 1993, pp. 1-3) to increase the available aquatic habitat at Phantom Lake Spring. Winemiller and Anderson (1997, pp. 204-213) showed that the refuge canal, although it was an artificial habitat, was used by endangered fish species when water was available. Stomach analysis of the endangered pupfish from Phantom Lake Spring showed that the amphipods were a part of the fish's diet (Winemiller and Anderson 1997, pp. 209-210). The refuge canal was constructed for a design flow down to about 0.5 cfs (0.01 cms), which at the time of construction was the lowest flow ever recorded out of Phantom Lake Spring. Recent loss of spring flow has eliminated the usefulness of the refuge canal because it is has been dry since the summer of 2000 (Allan 2000, p. 51).

Phantom Lake Spring ceased flow during the summer of 2000 and has not recovered except for short periods during local recharge events. All that remained of the spring outflow habitat was a small pool of water, with about 540 $ft^2$ (50 $m^2$) of surface area. In May 2001, Reclamation, in cooperation with the Service, installed an emergency pump to move water from within the cave to the springhead, as a temporary measure to prevent complete drying of the pool. Habitat for the amphipods at Phantom Lake Spring is now limited to this small pool. Despite the fact that Phantom Lake Spring has been drastically altered from its original state, the native aquatic fauna are maintaining minimal populations there. Hubbs (2001, pp. 323-324) documented changes in water quality (increased temperature, decreased dissolved oxygen, and decreased coefficient of variation for pH, turbidity, ammonia, and salinity) and fish community structure at Phantom Lake Spring since natural flows ceased. Starting in the summer of 2004, Phantom Lake Spring experienced flood flows sporadically over the subsequent two years. However, within a few months following these increases, flows returned to at or near zero.

The current status of aquatic habitat at Phantom Lake Spring is very poor. Efforts are ongoing to improve the pump system, but so far conservation actions have not enhanced the situation. The pump system failed several times during 2008, resulting in stagnant pools and near drying conditions. The pump system was stabilized in 2009 and the species remains extant but natural spring flows do not appear to be recovering. The loss of the population of the species at Phantom Lake Spring appears imminent.

*San Solomon Spring:* San Solomon Spring, in Reeves County, is by far the largest spring in the Balmorhea area (Brune 1981, p. 384). It provides the water for the swimming pool at Balmorhea State Park and most of the irrigation water for the Water District. Balmorhea State Park encompasses about 45.9 ac (18.6 ha) southwest of Balmorhea in Reeves County. The park is owned and managed by Texas Parks and Wildlife Department (TPWD). Park facilities were built by the Civilian Conservation Corps in the early 1930s and were opened as a state park in 1968. The entire spring head was converted into a concrete-lined swimming pool. The outflow from the pool is completely contained in concrete irrigation channels. A refuge canal encircling the historic motel was also built in 1974 to create habitat for the endangered fishes.

In 1996, TPWD created the San Solomon Ciénega (located on the Park, a few hundred meters downstream of the spring opening/swimming pool and adjacent to irrigation canals) which uses some spring flow to recreate more natural aquatic habitats for the benefit of the endangered fishes in Balmorhea State Park (McCorkle *et al*. 1998, pp. 36-40; Garrett 2003, pp. 151-160). It was designed to resemble and function like the original ciénega for the native aquatic fauna. The Water District and the local community it represents agreed to provide the essential water needed to create a secure environment for the endangered species. The main purpose of this restoration project was to recreate vital habitat, not only for the two endangered fishes, but for other aquatic, terrestrial, and wetland-adapted organisms as well (McCorkle *et al*. 1998, pp. 36-41; Garrett 2003, pp. 151-160).

The concrete canal encircling the motel was deteriorating and causing problems with the foundation of the motel. In 2009 and 2010 TPWD, in consultation with and funding assistance from the Service, constructed a second small additional ciénega habitat just north of the existing refuge canal. By relocating the canal to the north and providing a new ciénega, the aquatic habitat available for the native fishes and invertebrates at the Park will be increased in size and enhanced in nature. The project is being completed in 2010 (Lockwood 2010).

The artesian spring issues from the lower Cretaceous limestones at an elevation of 3,346 ft (1,020 m). Although long-term data are scarce, San Solomon Spring flows have declined somewhat over the history of record, but not as much as Phantom Lake Spring (Schuster 1997, pp. 86-90; Sharp *et al*. 1999, p. 4). Some recent declines in overall flow have likely occurred due to drought conditions and declining aquifer levels (Sharp *et al*. 2003, p. 7). San Solomon Spring discharges are usually in the 20 to 30 cfs (0.6 to 0.8 cms) range (Ashworth *et al*. 1997, p. 3; Schuster 1997, p. 86) and are consistent with the theory that the water bypassing Phantom Lake Spring discharges at San Solomon Spring.

*Giffin Spring:* This spring is located less than 1.0 mi (1.6 km) west, across State Highway 17, from Balmorhea State Park. Access is limited because the spring is on private property. Brune (1981, pp. 384-385) documented a gradual decline in flow from Giffin Spring between the 1930s and 1970s, but surprisingly the discharge has remained near constant in recent decades, with outflow of about 3 to 4 cfs (0.08 to 0.1 cms) (Ashworth *et al*. 1997, p. 3). The outflow channel has been modified (dammed and channelized) to accommodate irrigation for downstream canals.

*East Sandia Spring*: East Sandia Spring is located approximately 2 mi (3.2 km) east of Balmorhea near the community of Brogado. The Spring is included in a 240-ac (97-ha) preserve owned and managed by TNC (Karges 2003, pp. 145-146). Included on the site, a significant sacaton grassland (coarse grass) is associated with the habitat.

Flows from East Sandia Spring are likely from a shallow groundwater source as water chemistry differences indicate it is not directly connected with other Toyah Basin springs (San Solomon

Spring, Phantom Lake Spring, and Giffin Spring) in the nearby area (Schuster 1997, pp. 92-93). East Sandia Spring discharges at an elevation of 3,224 ft (977 m) from alluvial sand and gravel (Schuster 1997, p. 92). Brune (1981, p. 385) noted that flows from Sandia Springs were declining. East Sandia may be very susceptible to over pumping in the area of the local aquifer that supports the spring. Measured discharges in 1995 and 1996 ranged from 0.45 to 4.07 cfs (0.013 to 0.12 cms) (Schuster 1997, p. 94). The small outflow channel from East Sandia Spring has not been significantly modified and water flows into the Water District irrigation system about 328 to 656 ft (100 to 200 m) after surfacing. West Sandia Spring also occurs on the TNC preserve, but it ceased flowing over long periods of time (Schuster 1997, p.93). The presence of rare species there is not likely.

*Irrigation Canals*: The Water District maintains an extensive system of over 60 mi (97 km) of irrigation canals that provide minimal aquatic habitat for the native species. Most of the canals are concrete-lined with high velocities and little natural substrate available. Many of the canals are regularly dewatered as part of the normal Water District operations for water management.

*Climate Change:* Future climate change may also impact water quantity and habitat maintenance for this aquatic species. According to the Intergovernmental Panel on Climate Change (IPCC 2007, p. 1), "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Localized projections suggest the southwest U.S. may experience the greatest temperature increase of any area in the lower 48 states (IPCC 2007, p. 8), with warming increases in southwestern states greatest in the summer. The IPCC also predicts hot extremes, heat waves, and heavy precipitation will increase in frequency (IPCC 2007, p. 8). Karl *et al*. (2009, p. 12) suggest that warming of the United States climate is already happening and is increasing.

There is also high confidence that many semi-arid areas like the western United States will suffer a decrease in water resources due to climate change (IPCC 2007, p. 7; Karl *et al*. 2009, pp. 129-131), as a result of less annual mean precipitation and reduced length of snow season and snow depth. Milly *et al*. (2005, p. 347) also project a 10 to 30 percent decrease in precipitation in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models. Even under lower emission scenarios, recent projections forecast a 4 to 6 ºF (2 to 3 ºC) increase in temperature and a 10 percent decline in precipitation in western Texas by 2080-2099 (Karl *et al*. 2009, pp. 129-130). Assessments of climate change in west Texas suggest that the area is likely to become warmer and possibly slightly drier (TWDB 2008, pp. 22-25).

The potential effects of future climate change could reduce overall water availability in this region of western Texas and compound the threat of declining flows from the San Solomon Spring system. If this were to occur, spring flows could decline directly because of decreases in recharge from declining precipitation or indirectly as a result of increased pumping of groundwater to accommodate human needs for additional water supplies (Mace and Wade 2008, p. 664). Other potential effects of climate change on the physical and biological environment of the springs are possible, but difficult to predict as no formal vulnerability assessment has been completed. The species may be highly sensitive to the effects of climate change because its habitat is closely dependent on stable flows (from precipitation) and water temperatures. Other indirect effects of climate change include alteration of water quality, invasion of nonnative species, increased disease susceptibility, or other factors are also possible. We lack sufficient certainty to know how climate change may specifically affect this species. However, because of the extremely small range and dependence on specific environmental conditions, any potential changes to its environment could result in the extinction of the species.

The species also has no opportunity to migrate and it is unlikely it could be successfully relocated to alternate environments. As a consequence, its capability to adapt to environmental changes from climate change is presumed low. Therefore, although the imminence of the threats related to climate change can be considered low, the magnitude of effects of those changes on the species is considered high.

Habitat Quality: Another threat to the diminutive amphipod habitat is the potential degradation of water quality from point and nonpoint pollutant sources. This can occur either directly into surface water or indirectly through contamination of groundwater that discharges into spring run habitats used by the amphipod. The primary threat for contamination comes from herbicide and pesticide use in nearby agricultural areas.

The natural ciénega habitats of the Balmorhea area have been mostly altered over time to accommodate agricultural irrigation. Most significant was the draining of wetland areas and the modification of spring outlets for development of human use of the water resources. Although the physical condition of the areas has changed dramatically over time as a result of human actions, at least a portion of the native biota remain. Three of the four known occurrences of the species are in degraded habitats (exception is East Sandia Spring) because the natural conditions of the springs have been substantially modified for human use. Any additional modifications to the spring flow habitats will further threaten the species.

Conclusion: Based on our evaluation of current spring modifications, loss of spring integrity, and groundwater withdrawals and climate change, we conclude the diminutive amphipod is threatened due to the present and threatened destruction, modification, or curtailment of its habitat and range.

B. Overutilization for commercial, recreational, scientific, or educational purposes.
Overutilization is not known to be a factor threatening the diminutive amphipod.

C. Disease or predation.
Disease and predation are not known to be factors threatening the diminutive amphipod. However, the presence of the introduced species (*Melanoides* snail) increases the potential for diseases to affect the species (See Factor E), but there is not sufficient information to conclude that disease is currently a threat to the species.

D. The inadequacy of existing regulatory mechanisms.
Texas State law provides no protection for this invertebrate species. There are no existing Federal, State, or local regulatory mechanisms providing protection for these species. However, the amphipod is afforded some protection indirectly due to the presence of two fishes (Comanche Springs pupfish and Pecos gambusia) listed as endangered, by state and Federal governments,

and that occupy similar habitats. However, the diminutive amphipod may be more sensitive to changes in water quality or other habitat changes than the fish and are likely more directly threatened by the presence of the exotic *Melanoides* snail than the endangered fish (see Factor E below).

Some protection for the habitat of this species is provided with the ownership of the springs by Federal (Phantom Lake) and State (San Solomon) agencies, and by TNC (East Sandia). However, this land ownership provides no protection for maintaining necessary groundwater levels to ensure adequate spring flows. Texas groundwater resources were historically under the "Rule of Capture," which provides limited opportunity for regulation of pumping or management of groundwater resources (Potter 2004, pp. 1-10). Local underground water districts are now the method for groundwater management in Texas. Although there are three groundwater districts in the area that could manage groundwater to protect spring flows, it is uncertain if the district would limit groundwater use to provide for conservation of surface water flows for natural resource benefits (Booth and Richard-Crow 2004, p. 38; Caroom and Maxwell 2004, pp. 53-54).

Therefore, based on our evaluation, we conclude that the protections from the existing regulatory mechanisms are not adequate to limit or alleviate the threats to the diminutive amphipod, even considering the protections resulting from the co-occurrence of the two federally-endangered fishes.

E. <u>Other natural or manmade factors affecting its continued existence</u>.

Exotic Species

During the 1990s, an exotic snail, *Melanoides* spp., was discovered in Phantom Lake Spring (B. Fullington, University of Texas-El Paso *in litt*., 1993; McDermott 2000, pp. 1-43). The species has been at San Solomon Spring for some time longer, but is not found in East Sandia Spring. In many locations at San Solomon Spring, this exotic snail dominates the substrate in the small stream channel. The effects of this introduction are not known. However, this exotic snail may be competing with the diminutive amphipod for space and resources. Other changes to the ecosystem from the dominance of this species could occur and could have detrimental effects to the native invertebrate community.

Limited Distribution and Stochastic Events

The diminutive amphipod may be susceptible to threats associated with limited distribution and impacts from stochastic events. Stochastic events from either environmental factors (random events such as severe weather) or demographic factors (random causes of births and deaths of individuals) are also heightened threats to the species because of the limited range (Melbourne and Hastings 2008, p. 100). Finally, the small range of this amphipod does not provide any opportunity for natural recolonization if any of these factors resulted in a local extirpation event.

Based on our evaluation, we conclude that the diminutive amphipod is threatened by the impacts of other natural and manmade factors, including exotic species, climate change, and limited distribution.

CONSERVATION MEASURES PLANNED OR IMPLEMENTED: This species is designated as a high priority species in the Wildlife Action Plan of Texas (TPWD 2005, p. 354). The Service has had a long and active partnership with the Water Improvement, TPWD, TNC, Reclamation, and others in conservation of the endangered fishes that occur in the springs and irrigation system in the Balmorhea area of Reeves and Jeff Davis counties. The benefits of these partnerships extend to the conservation of endemic invertebrates as well. TPWD owns and manages Balmorhea State Park, not only for the benefit of visitors, but also for the conservation of the rare and protected aquatic species. The San Solomon Ciénega project by TPWD, the Water District, and a host of other cooperators was a significant step in conservation of the area's aquatic biota (McCorkle *et al*. 1998, pp.36-41) and increased habitat available for the amphipods. TPWD provides some management assistance to Reclamation for maintenance of the property at Phantom Lake Spring.

There is ongoing research on taxonomy and phylogeny of amphipods in west Texas thanks to efforts of the New Mexico Department of Game and Fish studying similar species in New Mexico. This work has provided much of the biological information on which this assessment is based. In addition, the Service has been working with TPWD and Reclamation to maintain the aquatic habitat at Phantom Lake Spring through the installation and maintenance of a pumping system there. Section 6 funds (Grant No. TX-E-53) have been used to upgrade this pumping system to continue this project.

The Service provided funds (through a section 6 grant) to the Texas Water Development Board to conduct a regional groundwater study (Grant No. TX-E-19). The purposes of the study included investigating the source of groundwater that supports area springs and determining the causes for spring flow declines at Phantom Lake Spring. The final study was completed by the Texas Water Development Board in May 2005 (Texas Water Development Board 2005); however, there were no conclusive results that suggested the cause of the decline in spring flow was directly related to human activities.

In August 2009, TPWD was issued a 10(a)(1)(B) permit and Habitat Conservation Plan (HCP) for the Management Plan for Balmorhea State Park. This plan authorizes "take" of endangered fish in the park for ongoing management activities while minimizing impacts to the aquatic species, particularly the endangered fish. The activities included in the HCP are a result of TPWD operation and maintenance of the Park, including the draw downs associated with cleaning the swimming pool and vegetation management within the refuge canal and ciénega. The HCP authorizes a very small amount of take of the covered fish species, but contains conditions for TPWD to ensure compliance with the Act by demonstrating measures to minimize and mitigate any possible adverse effects to the covered species (Permit No. TE-183172-0).

During 2009 and 2010, TPWD removed a portion of the existing refuge canal and relocated it away from the motel and constructed a new ciénega habitat at Balmorhea State Park. This will provide additional natural habitat for the endangered fishes and candidate invertebrates. The Service cooperated on this project by providing funds through a section 6 grant to TPWD for the design and construction of the project (Lockwood 2010).

SUMMARY OF THREATS:  The primary threat to the diminutive amphipod is the loss of surface flows due to declining groundwater levels.  Although much of the land immediately surrounding their habitat is owned and managed by TNC, Reclamation, and TPWD, the water needed to maintain their habitat has declined due to a reduction in spring flows, possibly as a result of private groundwater pumping in areas beyond those controlled by these landowners and worsened by low rainfall in the region.  As an example, Phantom Lake Spring, one of the sites of occurrence, has already ceased flowing, and aquatic habitat is supported only by a pumping system.  In addition, the potential effects of future climate change could further exacerbate the impacts of declining groundwater availability.

We find that the diminutive amphipod is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

RECOMMENDED CONSERVATION MEASURES:  Needed conservation measures for the near-term include: maintaining spring flows in all of the San Solomon Spring System through groundwater management and conservation; monitoring the distribution, abundance, and habitat use of the amphipod; and establishing a captive propagation program for the species.

LISTING PRIORITY:

| THREAT | | | |
|---|---|---|---|
| Magnitude | Immediacy | Taxonomy | Priority |
| **High** | **Imminent** | Monotypic genus | 1 |
| | | **Species** | 2* |
| | | Subspecies/population | 3 |
| | Non-imminent | Monotypic genus | 4 |
| | | Species | 5 |
| | | Subspecies/population | 6 |
| Moderate to Low | Imminent | Monotypic genus | 7 |
| | | Species | 8 |
| | | Subspecies/population | 9 |
| | Non-imminent | Monotypic genus | 10 |
| | | Species | 11 |
| | | Subspecies/population | 12 |

Rationale for listing priority number:

*Magnitude:*  HIGH.  All four known sites of occurrence face the threat of loss of spring flow.  Threats of spring flow loss will result in complete habitat loss and permanent elimination of entire populations of the species.

*Imminence:* IMMINENT. Drying of Phantom Lake Spring is currently occurring and may extirpate this population in the near future. Declining spring flows in San Solomon Spring is also becoming evident and will impact that spring site as well within the foreseeable future.

_Yes._ Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed?

Is Emergency Listing Warranted? No. Emergency listing of the diminutive amphipod is not warranted at this time. Because the amphipod is sympatric with the two endangered fishes, it benefits from ongoing conservation actions to recover these fishes. In addition, the nature of the main threat of spring flow loss is not a straightforward enforcement action under the Endangered Species Act, and, therefore, emergency listing of the diminutive amphipod is not likely to afford them immediate protection that would either alleviate the threats or prevent extinction.

DESCRIPTION OF MONITORING: Since the phylogenetic study of these amphipods began in about 2000, collections of amphipods from the Toyah Basin have been made irregularly on several occasions. Since the diminutive amphipod reoccurred (or was re-documented) at Phantom Lake Spring in 2001, Service personnel have monitored the habitat at Phantom Lake Spring (maintained by a pumping system) over the last few years and monitored presence of the amphipod several times per year, most recently trips made in May and September 2009 (Allan 2009a, 2009b). In addition, partners from TPWD, Reclamation, New Mexico Department of Game and Fish, Lehigh University, and others provide irregular monitoring of the pump system and biota (observation) at Phantom Lake Spring. Spring habitats are generally monitored by TPWD and TNC at San Solomon and East Sandia springs, respectively. Flows from San Solomon Spring are monitored by U.S. Geological Survey, Reclamation, and the Water District on a continual basis.

Aquatic invertebrates were sampled at San Solomon Spring and Phantom Lake Spring in June, September, and December 2008 by personnel from Miami University-Ohio and New Mexico Department of Game and Fish. All three candidate invertebrates were present in good numbers at San Solomon Spring in each survey (Lang 2008, New Mexico Department of Game and Fish, pers. comm.). No diminutive amphipods or Phantom springsnails were collected at Phantom Lake Spring, in June and September 2008. Only one Phantom Cave snail was collected. However, in early December 2008 all three species were again found and "showed sign of active reproduction—juveniles present (Lang 2008, New Mexico Department of Game and Fish, pers. comm.). Presence/absence monitoring of the species at Phantom Lake Spring in May and September 2009 confirms it is continuing to persist at that highly vulnerable location.

COORDINATION WITH STATES

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:
On March 4, 2010, the Service contacted TPWD by email requesting information on the status of this and other candidate species. They provided no new information in their March 30, 2010, email response (Wendy Gordon, TPWD, pers. comm, 2010).

Indicate which State(s) did not provide any information or comments: NA

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APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

| | | |
|---|---|---|
| Approve: | ______________________________ | May 21, 2010 |
| | Acting Regional Director, Fish and Wildlife Service | Date |
| Concur: | ______________________________ | ______________ |
| | Director, Fish and Wildlife Service | Date |
| Do not concur: | ______________________________ | ______________ |
| | Director, Fish and Wildlife Service | Date |

Director's Remarks:

Date of annual review: April 2010
Conducted by: Nathan Allan

Comments: